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FORM PTO-1390 U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE
REV. 2/01T

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371

ATTORNEY'S DOCKET NUMBER
03438.0082

U.S. APPLICATION NO. (If known, see 37CFR1.5)
09/937304

INTERNATIONAL APPLICATION NO.	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED
PCT/NO00/00105	March 23, 2000	March 26, 1999

TITLE OF INVENTION
DEVICE AND SYSTEM FOR MONTIORING INTERNAL TEMPERATURE OF INACCESSIBLE OR MOVING PARTS

APPLICANT(S) FOR DO/EO/US
Andreas JAGTØYEN

Applicant(s) herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. X This is a **FIRST** submission of items concerning a filing under 35 U.S.C 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☐ This is an express request to begin national examination procedures (35 U.S.C. 371(f)). The submission must include items (5), (6), (9) and (21) indicated below.
4. X The US has been elected by the expiration of 19 months from the priority date (Article 31).
5. X A copy of the International Application as filed (35 U.S.C. 371 (c)(2)).
   a. ☐ is attached hereto (required only if not communicated by the International Bureau.
   b. X has been communicated by the International Bureau.
   c. ☐ is not required, as the application was filed with the United States Receiving Office (RO/US).
6. X An English language translation of the International Application as filed (35 U.S.C. 371 (c)(2)).
   a. X is attached hereto.
   b. ☐ has been previously submitted under 35 U.S.C. 154 (d)(4).
7. X Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371 (c)(3)).
   a. ☐ are attached hereto (required only if not communicated by the International Bureau).
   b. ☐ have been communicated by the International Bureau.
   c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
   d. X have not been made and will not be made.
8. ☐ An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371 (c)(3)).
9. ☐ An oath or declaration of the inventor(s) (35 U.S.C. 371 (c)(4)).
10. X An English language translation of the annexes of the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371 (c)(5)).

Items 11 to 20 below concern document(s) or information included:

11. ☐ Information Disclosure Statement under 37 CFR 1.97 and 1.98
12. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. ☐ A FIRST preliminary amendment.
14. ☐ A SECOND or SUBSEQUENT preliminary amendment.
15. ☐ A Substitute specification.
16. ☐ A change of power of attorney and/or address letter.
17. ☐ A computer-readable form of the sequence listing in accordance with PCT Rule 13ter.2 and 35 U.S.C. 1.821-1.825.
18. ☐ A second copy of the published international application under 35 U.S.C. 154 (d)(4).
19. ☐ A second copy of the English language translation of the international application 35 U.S.C. 154 (d)(4).
20. X Other items or information:
   a. X Copy of cover page of International Publication No. WO 00/62029
   b. ☐ Copy of Notification of Missing Requirements.
   c. ☐

U.S. APPLICATION NO. (If known, see 37CFR 1.5)	INTERNATIONAL APPLICATION NO.	ATTORNEY'S DOCKET NUMBER
09/937304	PCT/NO00/00105	03438.0082

21. ☒ The following fees are submitted: — CALCULATIONS PTO USE ONLY

BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)):

Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO **$1000.00**

International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO **$860.00**

International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search fee (37 CFR 1.445(a)(2)) paid to USPTO **$710.00**

International preliminary examination fee (37 CFR 1.482) paid to USPTO but all claims did not satisfy provisions of PCT Article 33(1)-(4) **$690.00**

International preliminary examination fee (37 CFR 1.482) paid to USPTOand all claims satisfied provisions of PCT Article 33 (1)-(4) **$100.00**

ENTER APPROPRIATE BASIC FEE AMOUNT =	$1000.00	
Surcharge of $130.00 for furnishing the oath or declaration later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492 (e)).	$	

CLAIMS	NUMBER FILED		NUMBER EXTRA	RATE		
Total Claims	16	- 20 =		x $18.00	$	
Independent Claims	2	-3 =		x $80.00	$	
MULTIPLE DEPENDENT CLAIM(S) (if applicable)				+$270.00	$270.00	
				TOTAL OF THE ABOVE CALCULATIONS =	$1270.00	
☐ Applicant claims small entity status. See 37 CFR 1.27. The fees indicated above are reduced by ½.					$	
				SUBTOTAL =	$1270.00	
Processing fee of **$130.00** for furnishing the English translation later than ☐ 20 ☐ 30 months from the earliest priority date (37 CFR 1.492(f)).					$	
				TOTAL NATIONAL FEE =	1270.00	
Fee for recording the enclosed assignment (37 CFR 1.21 (h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). **$40.00** per property. +					$	
				TOTAL FEES ENCLOSED =	$1270.00	
					Amount to be refunded:	$
					charged:	$

a. X A check in the amount of $ 1270.00 to cover the above fees is enclosed.

b. ☐ Please charge my Deposit Account No. _____ in the amount of $ _____ to cover the above fees. A duplicate copy of this sheet is enclosed.

c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 06-0916. A duplicate copy of this sheet is enclosed.

d. ☐ Fees are to be charged to a credit card. **WARNING:** Information on this form may become public. **Credit card information should not be included on this form.** Provide credit card information and authorization on PTO-2038.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137 (a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:

Finnegan, Henderson, Farabow, Garrett & Dunner, L.L.P.
1300 I Street, N.W.
Washington, D.C. 20005-3315

DATED: September 25, 2001

SIGNATURE

Ernest F. Chapman Reg. No. 25,961

NAME/REGISTRATION NO.

Device and system for monitoring internal temperature of inaccessible or moving parts.

The invention relates to a device and a system for monitoring temperature inside inaccessible and/or movable parts.

In large or medium-sized machines and engines, such as for example diesel engines, there are many bearings which may be damaged during operation. In order to prevent this the standard procedure to date has been to monitor such bearings by means of continuous temperature or vibration measurement, or by periodic measurements of the same parameters. In large diesel engines requirements have been introduced from classification societies regarding temperature monitoring of main bearings. These requirements, however, have not been introduced in connection with crankshaft bearings, the reason being that no equipment exists which is suitable for measuring this temperature.

For 4-stroke medium and high-speed diesel engines it will be an enormous advantage if damage to the crankshaft bearings can be detected at an early stage. In these engines the damage can develop quickly, and the consequences of a crankshaft bearing breakdown are often highly dramatic.

Serious engine damage usually occurs when primary damage (initiating damage) leads to engine breakdown. An example of such primary damage may be that the piston loses the lubrication in the cylinder due to carbon formation on the piston crown, or due to a fault in the combustion in the cylinder. The piston will begin to move sluggishly, thereby inflicting greater loading/surface pressure on the crankshaft bearing. Another example of primary damage which can result in serious engine damage is lubricating oil failure to the crankshaft bearing on account of failure in the supply from the lube oil pump or clogged oil channels in the crankshaft. A final example of primary damage which may be mentioned in this connection is when a crank bolt loosens or breaks.

In all probability, all of the above-mentioned situations will inflict enormous damage on the engine, especially on the crankshaft, piston rod (connecting rod), and the engine block. In many cases the piston rod is torn loose from its attachment in the piston (which cracks), and in the worst case some of the rotating parts may be thrown out of the engine. Developments of this kind may entail great risk for the engine-room crew if they are in the vicinity of

the engine. If the engine is providing for a ship's propulsion, the ship may lose its propulsion and manoeuvring ability over a considerable period, which can result in running aground and pollution problems.

A sufficiently fast temperature sensor will enable the engine to be shut down so early that such serious damage can be avoided and in the worst case it will only be necessary to replace parts or carry out repairs in connection with the primary damage which caused the temperature increase.

So far the problem has been described in connection with engine parts in general and crankshaft bearings in large and medium-sized diesel engines in particular. However, similar problems occur in connection with a number of rotating parts, for example in electric motors, wheel bearings, brake discs and so on.

In SE-B-391.031 a device is described for measuring temperature in a movable mechanical part. The publication shows how this device can be employed for monitoring the temperature in the crosshead bearing in a diesel engine. In this device the sensor is a temperature-sensitive resistor, and the transmission of the test signals is performed capacitively. Similar solutions also exist where the signal transmission is performed by means of sliding contacts or inductively. There is an element of uncertainty concerning the measurement in all of these alternatives due to the fact that the circuits' electrical properties can change, and none of them permit transmission of data without electrical contact other than over extremely short distances.

WO 97/09596 describes a sensor for detection of status data, including temperature, in an electric motor. The sensor is formed from a surface wave acoustic element, or a SAW chip. The SAW chip's properties are altered as a function of the physical conditions which have to be measured, which results in alteration of the transmitting function. A polling signal in the form of a radio signal with specific properties is transmitted from a polling unit and received by the SAW chip. There it is converted to an electrical signal and then to an acoustic signal which is transmitted along the element's surface and reflected, whereupon it is converted back first to an electrical signal and then to a radio signal which is returned to the polling unit. There the physical status data are derived based on the changes in the polling signal which are a result of changes in the SAW chip's transmitting function. The publication

describes how it is possible to place the sensor inside a winding and connect it to an antenna which is located on the outside thereof. However, it does not describe how such a sensor may be designed in order to be capable of being installed in a suitable manner and to be sufficiently robust to be used in a particularly harsh environment.

A similar sensor is described in WO 93/13495, intended for wheel bearings and brake blocks on trains.

SAW chips, however, are not particularly robust in a harsh environment, and in the previously known applications it has only been proposed that they should be installed on the surface of the component which is to be monitored. This is due first of all to the fact that it is simple and requires no modification to the actual component, and secondly that if the SAW chip were located inside the component it would be difficult to transmit the polling signal, since the component which is to be monitored would act as a screen. The previously known sensors of this type are therefore not suitable for a great many applications, especially in connection with engines and particularly for measuring temperature deeper inside a component than at the surface.

US-A-5.438.322 discloses a temperature sensor which is in the form of a bolt. However, it contains a radio transmitter which, if the temperature exceeds a certain critical value, is pressed against the bolt's surface and activated, thus causing an alarm signal to be transmitted. The sensor can therefore not supply information on what the actual temperature is, but is only designed to emit an alarm signal if a threshold is exceeded.

In contrast to the previously known solutions, the present invention provides a sensor which is robust with regard to a harsh environment, and which can also be employed for measuring the temperature deep inside the component which is to be monitored. Furthermore, the invention makes it possible to transmit temperature data from the sensor to a receiver even though the sensor is installed on a part which is movable relative to the receiver and is located at a certain distance from the receiver.

The above-mentioned characteristics are achieved by means of the characterising features which are set forth in the independent claims.

In addition to the characteristics which are mentioned above, the invention provides a system which can easily be mounted in already-existing installations. This installation may, for example, be performed by fitters from the equipment supplier. Thus there is no requirement that suppliers of engines and other machines should design these systems in such a manner that they are ready for use together with the present invention.

The invention will now be described in further detail in the form of an exemplary embodiment and with reference to the attached drawings, in which:

fig. 1 is a principle drawing of an application where the invention is used for measuring temperature in crankshaft bearings,

fig. 2 illustrates a SAW chip which can be employed as a sensor element in the present invention,

fig. 3 illustrates the design of a sensor for temperature monitoring according to the present invention,

fig. 4 illustrates an alternative design of a sensor for temperature monitoring according to the present invention,

fig. 5 illustrates another alternative design of a sensor for temperature monitoring according to the present invention,

fig. 6 illustrates the use of the present invention in monitoring a ship's engine installation.

Figure 1 illustrates how the present invention can be employed in a system for measuring temperature in crankshaft bearings, especially in large and medium-sized diesel engines. The system consists of four main components, viz. sensors 1 (preferably one for each cylinder), antennae 2 (preferably one for each sensor), a control unit 3 and a recording unit 4. Here the sensors 1 are installed freely in the crankshaft bearing housing. The antennae 2 are installed inside the engine and connected to the control unit 3 which preferably comprises a multiplexer to enable test data to be received from more than one antenna/sensor. The control unit 3 will preferably be installed near the engine and connected to the antennae 2 via signal cables 5. The recording unit 4 is preferably a computer with software for storing historical

data, display of test data in graphic and alphanumeric form, configuration of alarm limits, possibly communication with an alarm centre, printing of reports etc. This unit will preferably be placed in the control room for the machine or the engine which is to be monitored and it will be connected to the control unit via a standard connection for data transfer, for example a data bus solution 6. In many cases this computer could be a computer which is already located in such a control room, and which simultaneously runs other software associated with the operation of the machine which is to be monitored.

The control unit 3 is designed to be capable of transmitting a polling signal to one of the sensors via the multiplexer and the antenna 2 which is connected to the sensor concerned 1. This polling signal will be reflected in modified form (e.g. with time delay or phase change) from one or more points on the sensor's 1 surface, returned from the sensor to be received by the antenna 2, and then returned to the control unit 3 possibly via a multiplexer. In the control unit the modified signal will be evaluated and the temperature in the crankshaft bearing derived therefrom. The derived temperature is then transferred to the recording unit 4 for recording and further processing.

Figure 2 illustrates how the temperature-sensitive element itself may be designed. The element is composed of a SAW chip with a transducer 12, often called a interdigital transducer, and one or more reflectors 13. When a high-frequency signal is applied to the transducer 12, this signal will be converted to an acoustic signal which is transmitted along the SAW chip's surface, reflected at the respective reflectors 13 and returned to the transducer in the form of a modified signal composed of the signals reflected from the respective reflectors. The transducer 12 converts the reflected signals back to electrical signals which are emitted from the transducer. The characteristics of the signal path along the SAW chip's surface, however, are dependent on the temperature of the SAW chip. The SAW chip will therefore act as a signal processing element with temperature-dependent transfer function. Changes in the transfer function will be able to be derived from the characteristics of the reflected signal, and on this basis the temperature can be derived. This will be discussed in more detail below.

Figure 3 illustrates an example of how the sensor 1 may be designed. The actual temperature-sensitive element, the SAW chip 11, will normally be encapsulated in a housing. In the following, the component which is composed of the SAW chip and its encapsulation or housing are referred to as the sensor element 14. In this example the sensor element 14 is located in a bolt 15. The sensor element 14, however, may also be located freely in the part which is to be monitored, which will be described in more detail below. The element is installed, for example, in a holder or socket 16, which may also be a small circuit board, which in turn is connected to an antenna 17, for example by means of a transmission line 18, such as a coaxial cable. The antenna 17 is located in such a way that it projects out of the part which is to be monitored. The antenna 17 may be installed at the bolt's upper end, for example in the form of a small circuit board. In this example, therefore, the antenna is an integrated part of the bolt 1 which forms the sensor. However, the antenna may also be provided separately and connected to the sensor via an extension of said transmission line 18.

When a polling signal is received by the antenna 17, it is transferred to the sensor element 14 where the received signal is converted to an acoustic signal which is applied to the SAW chip, as already described. When the reflected signal is received by the transducer 12, it is converted from an acoustic to an electrical signal which is applied to the antenna 17 and is transmitted therefrom as the modified polling signal. This signal is received by the antenna 2 and further processed as described above.

The actual design of the bolt 15 can vary depending on what kind of environment the sensor 1 is to be placed in. In a preferred embodiment the bolt will be designed with external threads, thus enabling it to be screwed into the component in which it is to be installed. However, other designs are also possible. For example, the bolt 15 may be designed with a smooth surface or a surface with a certain degree of roughness, and forced into a narrow hole where it is secured by tension and friction. The inside of the bolt 15 will preferably be filled with a material 19 which keeps the respective components in position, for example epoxy or a heat-resistant rubber sleeve.

An alternative design is illustrated in figure 4, where the same or corresponding components to those illustrated in figure 3 have been given the same reference numbers. In this example the sensor element 14 is not

mounted inside a bolt. The bolt 15 in this case only serves to close the installation hole and secure the actual components. Instead, the sensor element 14 is mounted freely at the bottom of a hole in the part which is to be monitored. In the same way as in the example illustrated in figure 3, the sensor element may be mounted in a holder 16 and connected to a transmission line 18. This transmission line will in turn be connected to an antenna (not shown) on the outside of the part which is to be monitored. In the example in the figure it is shown how a spring 10 which is secured by the bolt 15 presses the sensor element 14 against the bottom of the hole. As an alternative to a spring, a sleeve may be employed made of a suitable material such as for example heat-resistant rubber. The hole may be filled with epoxy or the like, but it will not be a preferred solution in this embodiment, since it will make it difficult to remove/replace the sensor element 14 and the other components.

A further embodiment is illustrated in figure 5, where corresponding reference numbers to those in the previous figures are again employed. In this embodiment the sensor element 14 and the holder 16 are installed inside an encapsulation 15a which is closed by a screw 20 with a hole for passing through the transmission line 18. This passage may in turn be sealed, for example, by epoxy 19a. In its turn this encapsulation will be pressed against the bottom of the hole in which it is located by a spring 19b or a sleeve which in turn is kept in position by a bolt 15c with a hole for passing through the transmission line. In the example in the figure there is provided in this hole a screw 21 which presses a gasket or O-ring 22 against an internal surface 23 in the bolt 15b, with the result that the O-ring 22 tightly encloses the transmission line 18. The transmission line 18 in turn is connected to an antenna (not illustrated) on the outside of the part which is being monitored.

While the design which is described with reference to figure 3 is well-suited to standard lengths, i.e. when the actual temperature-sensitive element always is to be installed the same distance inside the part which is to be monitored, the embodiments which are illustrated in figures 4 and 5 are suitable for variable lengths, where the depth of the individual mounting hole determines how far into the part which is to be monitored the temperature-sensitive element is installed.

When installing the sensor in the component which is to be monitored, it is important to avoid causing it any damage which impairs the component unnecessarily. If the sensor is to monitor a component which is exposed to stress, as will be the case with a crankshaft bearing, it is therefore vital to prepare specifications for where and how the installation should take place, and that this task is performed by qualified specialists.

Figure 6 illustrates how the present invention can be employed in the monitoring of a ship's engine installation consisting of two main engines 31, 32 and two auxiliary engines 33, 34. A number of sensors with associated antennae are arranged in each engine as already described, and these are connected to a control unit 3 which in this example comprises a multiplexer or another form of selector which controls the signals to and from the respective sensors. The control unit 3 is preferably placed in the engine room near the engines. From the control unit 3 the signals are transmitted via a data bus 6 to a computer 4 which constitutes the recording unit described above and which is placed in the ship's control room. This is connected to a printer 35 and an alarm centre 36.

From the control unit 3 the computer 4 receives data signals carrying information on the temperature measured at the different sensors. This information preferably contains both temperature data and data identifying the individual sensor, but alternatively the computer 4 may control the multiplexer in the control unit 3 in such a manner that temperature data are always received from the sensor to which the computer chooses to transmit a polling signal. The received temperature data are stored in the computer, and temperature information can be displayed graphically or alphanumerically on the computer screen. Temperature lists and historical data can also be printed out on the associated printer.

The computer will preferably be programmed to react to temperatures which exceed defined alarm thresholds. If one of the sensors indicates a temperature higher than the defined temperature threshold, an alarm signal will be generated which is transmitted to an alarm centre 36. It may also be indicated on the computer that an alarm condition exists. The alarm centre may be designed in a number of different ways in order to indicate that an alarm condition exists in the form of visual or audible information. The alarm centre 36 or the computer 4 may also be arranged to shut off one or more of

the engines in the event of a predefined state of one or more alarms. It will also be possible to define several alarm levels for each individual sensor, such as, for example, for a visual alarm to be given at a first level, an audible alarm is activated at a second level, and at a third temperature level the drive speed or load on the engine or engines is lowered, or they are stopped.

It will be obvious to a person skilled in the art that within the scope of the invention it will be possible to implement a number of variations and alternatives. For example, the physical shape of the bolt 15 can be altered in order to be adapted to the component in which the sensor is to be mounted. Moreover, it will be appreciated that the sensor according to the invention is suitable for monitoring the temperature in a great many different components in machines and vehicles, and not only those which are mentioned herein. It will also be possible to perform the actual signal processing in the control unit in order to derive the temperature of the sensor in a number of different ways.

In a preferred embodiment the modified polling signal is composed of reflections from several points on the chip's surface, and with suitable measuring equipment the absolute phases from each individual reflection are measured. By combining these different absolute phases in order preferably to bring out certain differences between them, it is possible to determine the temperature unambiguously, and independently of the path which the signal has taken between sensor and control unit and the related delay. By calculating such differences, moreover, it is possible to achieve the same as is obtained by having a separate reference element with which the measurements are compared. It can therefore be said that one has a reference on the chip. In a preferred embodiment the actual polling signal will have a constant frequency which is amplitude or pulse modulated in order to be able to distinguish the modified polling signal from the original polling signal in the electronic metering circuits. It will also be possible to perform modifications which, for example, employ frequency-modulated polling signals (chirps).

It will also be clear to a person skilled in the art that the processing of the modified polling signal can be distributed between the control unit 3 and the recording unit 4, with certain properties of the signal being derived in the control unit and these being transferred to the recording unit for further

processing there, for example for comparison with calibration values for the sensor elements, which can be stored in the control unit or on data files in the recording unit.

09/937304
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PATENT CLAIMS

1. A device for measuring temperature of the inside of an inaccessible movable mechanical part, comprising a temperature-sensitive element with a SAW chip (11) with temperature-dependent transfer function, where the SAW chip has a transducer designed to be connected to an antenna (17) mounted on the outside of said part,
characterized in that the temperature-sensitive element is provided in an encapsulation (14; 15; 15a) which is designed to be placed and kept in position in a mounting hole in said moving part and thus to measure temperature inside the part, and that the device comprises a coaxial transmission line (18) for connecting the antenna (17) to the temperature-sensitive element, the device thus being adapted for measuring temperature deep inside the inaccessible mechanical part while this mechanical part is in motion.

2. A device according to claim 1,
characterized in that said encapsulation (14; 15; 15a) is composed of a hollow bolt (15, fig. 3) designed to be screwed into said mounting hole and where the temperature-sensitive element is arranged internally in the bolt while the antenna is provided at the part of the bolt which protrudes from said part.

3. A device according to claim 2,
characterized in that said bolt (15, fig. 3) is filled internally with a material (19) which keeps the temperature-sensitive element in position.

4. A device according to claim 3,
characterized in that said material (19) is epoxy or a heat-resistant rubber sleeve.

5. A device according to claim 1,
characterized in that said encapsulation (14; 15a) is designed to be arranged separately at the lower end of said mounting hole and that the device further comprises a bolt (15b) for closing the mounting hole and a material (19; 19a, 19b) which is designed to be placed between said bolt (15b) and the encapsulation (14; 15a), thus holding the encapsulation (14; 15a) securely in position after mounting.

6. A device according to claim 5,
characterized in that said material (19; 19a; 19b) is a spring which, when the device is mounted, presses the encapsulation (14; 15a) down against the lower end of the mounting hole.

7. A device according to claim 5,
characterized in that said material (19; 19a; 19b) is epoxy or a heat-resistant rubber sleeve.

8. A system for monitoring the temperature inside one or more inaccessible movable mechanical parts, where there is arranged inside the respective parts which are to be monitored at least one sensor (1) comprising a temperature-sensitive element with a SAW chip (11) with temperature-dependent transfer function, and where each SAW chip has a transducer which is connected to a respective first antenna (17) which is mounted on the outside of the respective part,
characterized in that the temperature-sensitive element is provided in an encapsulation (14; 15; 15a) which is placed and kept in position in a mounting hole in the respective mechanical part to measure temperature inside the part; that the temperature-sensitive element is connected to the first antenna via a transmission line (18),
that for each sensor (1) there is provided a second antenna (2) which is arranged in such a manner that it can transmit signals to and receive signals from this sensor (1) via said first antenna (17) while the part is in motion, said second antenna being connected via a signal cable (5) with a control unit (3) which, if the system contains more than one sensor (1), comprises a multiplexer; and
that the control unit (3) is arranged to be able to transmit a polling signal to and receive a modified polling signal from any of the sensors (1) via an associated signal cable (5) and associated second antenna (2) while the part is in motion, the control unit (3) being further arranged to process the received modified polling signal, and, on the basis of the characteristics of the modified polling signal, to generate a data signal which is representative for the temperature of the sensor (1).

9. A system according to claim 8,
characterized in that on said SAW chip there are provided a plurality of reflectors (13), and that the control device (3) is designed to be able to

measure the absolute phases of the components of the modified polling signal which are connected to the respective reflectors and to generate said data signal by means of the differences between these absolute phases.

10. A system according to claim 8 or 9, characterized in that the control device (3) is further connected to a recording device (4) via a data bus (6) and is arranged to transmit said data signal which is representative for the temperature of the sensor (1) to the recording unit (4).

11. A system according to claim 10, characterized in that the recording device (4) comprises a store for storing the received data signals or values which are derived therefrom and a display device for displaying information on these stored values graphically or in the form of alphanumeric characters.

12. A system according to claim 10 or 11, characterized in that the recording device (4) is arranged to generate a signal which indicates an alarm condition when it receives a data signal which indicates that the temperature at one of the sensors (1) is higher than a predefined threshold value.

13. A system according to claim 12, characterized in that said signal indicating an alarm condition activates a visual or audible alarm.

14. A system according to claim 12, characterized in that said signal indicating an alarm condition results in a reduction in the load, a reduction in the drive speed or shutting down of a machine, an engine or a process in which the part whose temperature is being monitored is included.

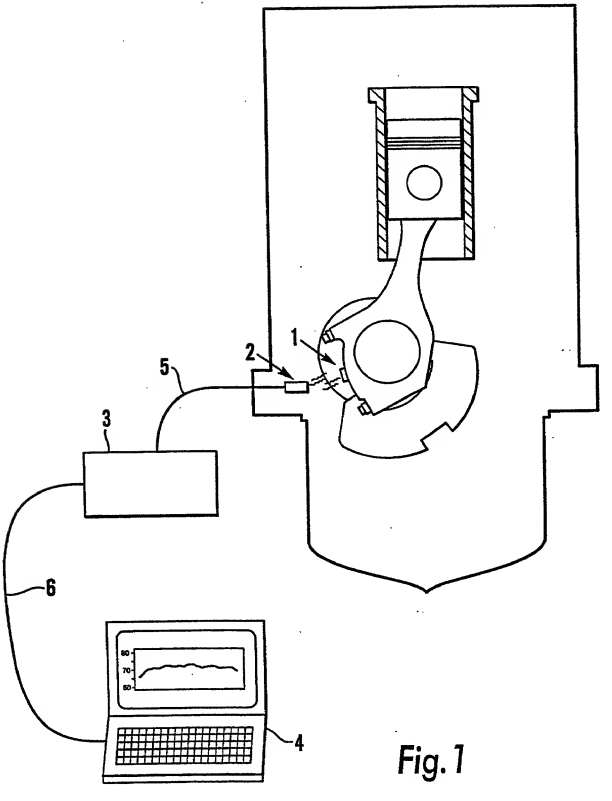

Fig. 1

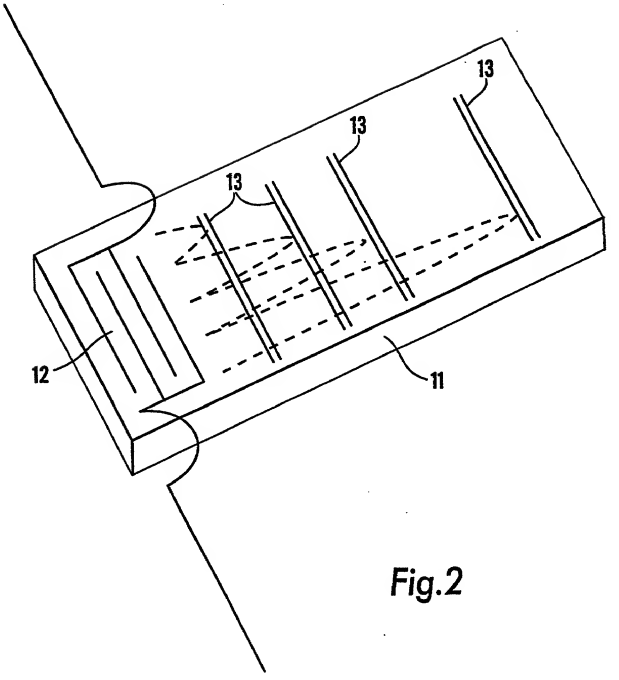

Fig.2

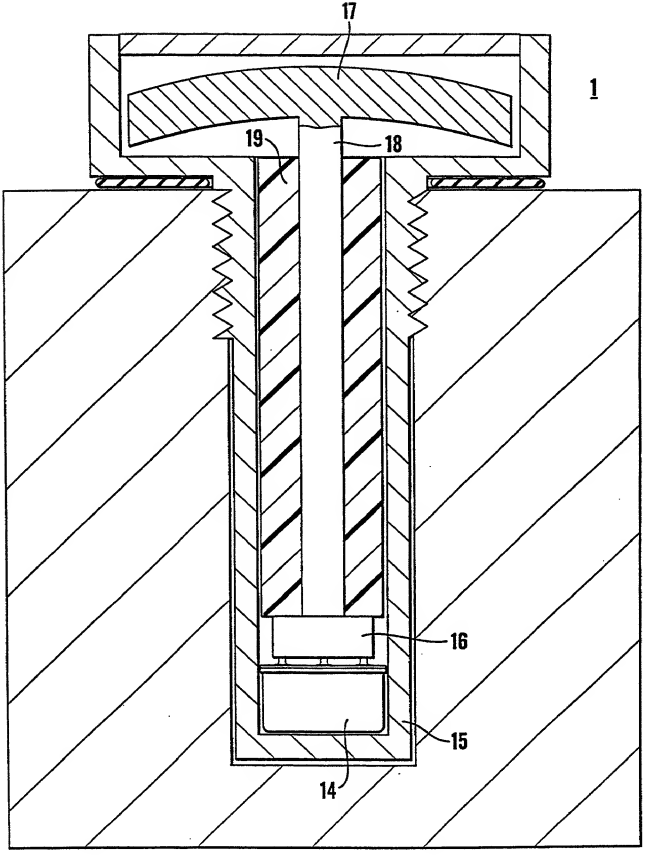

Fig.3

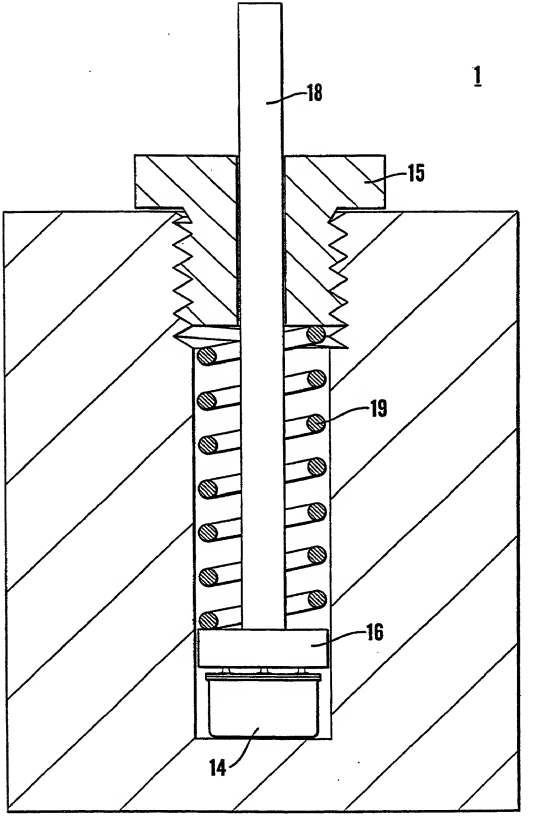

Fig.4

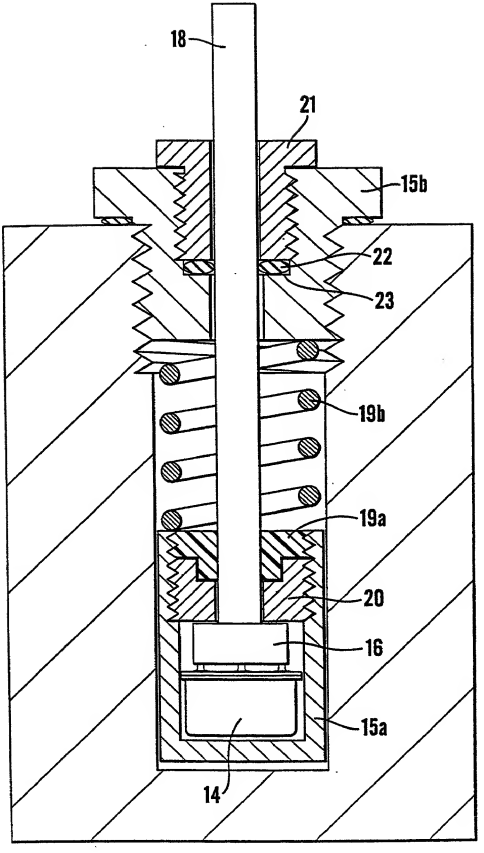

Fig.5

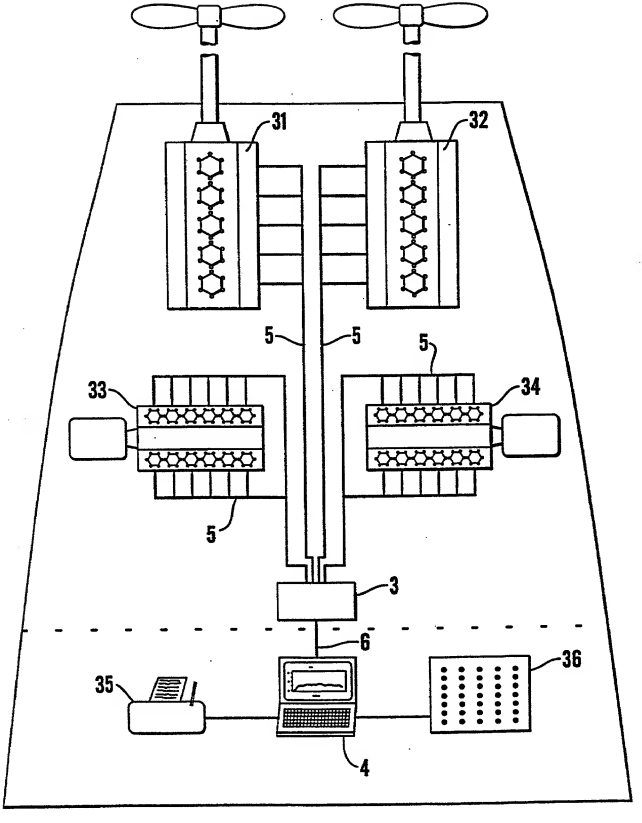

Fig.6

Attorney Docket No. 03438.0082

DECLARATION AND POWER OF ATTORNEY

As a below named inventor, I hereby declare that: my residence, post office address and citizenship are as stated below next to my name; I believe I am the original, first, and sole inventor (if only one name is listed below) or an original, first, and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled: DEVICE AND SYSTEM FOR MONITORING INTERNAL TEMPERATURE OF INACCESSIBLE OR MOVING PARTS the specification of which ☐ is attached and/or ☒ was filed on 25 Sept. 2001 as United States Application Serial No. _____ or PCT International Application No. PCT/NO00/00105 and was amended on _____ (if applicable).

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above. I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR § 1.56.

I hereby claim foreign priority benefits under 35 U.S.C. § 119(a)-(d) or § 365(b) of any foreign application(s) for patent or inventor's certificate or § 365(a) of any PCT international application(s) designating at least one country other than the United States, listed below and have also identified below, any foreign application(s) for patent or inventor's certificate, or any PCT international application(s) having a filing date before that of the application(s) of which priority is claimed:

Country	Application Number	Date of Filing	Priority Claimed Under 35 U.S.C.
Norway	19991514	26 March 1999	☒ YES ☐ NO
			☐ YES ☐ NO

I hereby claim the benefit under 35 U.S.C. § 119(e) of any United States provisional application(s) listed below:

Application Number	Date of Filing

I hereby claim the benefit under 35 U.S.C. § 120 of any United States application(s) or § 365(c) of any PCT international application(s) designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application(s) in the manner provided by the first paragraph of 35 U.S.C. § 112, I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR § 1.56 which became available between the filing date of the prior application(s) and the national or PCT international filing date of this application:

Application Number	Date of Filing	Status (Patented, Pending, Abandoned)

I hereby appoint the following attorney and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith. FINNEGAN, HENDERSON, FARABOW, GARRETT & DUNNER, L.L.P., Douglas B. Henderson, Reg. No. 20,291; Ford F. Farabow, Jr., Reg. No. 20,630; Arthur S. Garrett, Reg. No. 20,338; Donald R. Dunner, Reg. No. 19,073; Brian G. Brunsvold, Reg. No. 22,593; Tipton D. Jennings, IV, Reg. No. 20,645; Jerry D. Voight, Reg. No. 23,020; Laurence R. Hefter, Reg. No. 20,827; Kenneth E. Payne, Reg. No. 23,098; Herbert H. Mintz, Reg. No. 26,691; C. Larry O'Rourke, Reg. No. 26,014; Albert J. Santorelli, Reg. No. 22,610; Michael C. Elmer, Reg. No. 25,857; Richard H. Smith, Reg. No. 20,609; Stephen L. Peterson, Reg. No. 26,325; John M. Romary, Reg. No. 26,331; Bruce C. Zotter, Reg. No. 27,680; Dennis P. O'Reilley, Reg. No. 27,932; Allen M. Sokal, Reg. No. 26,695; Robert D. Bajefsky, Reg. No. 25,387; Richard L. Stroup, Reg. No. 28,478; David W. Hill, Reg. No. 28,220; Thomas L. Irving, Reg. No. 28,619; Charles E. Lipsey, Reg. No. 28,165; Thomas W. Winland, Reg. No. 27,605; Basil J. Lewris, Reg. No. 28,818; Martin I. Fuchs, Reg. No. 28,508; E. Robert Yoches, Reg. No. 30,120; Barry W. Graham, Reg. No. 29,924; Susan Haberman Griffen, Reg. No. 30,907; Richard B. Racine, Reg. No. 30,415; Thomas H. Jenkins, Reg. No. 30,857; Robert E. Converse, Jr., Reg. No. 27,432; Clair X. Mullen, Jr., Reg. No. 20,348; Christopher P. Foley, Reg. No. 31,354; John C. Paul, Reg. No. 30,413; Roger D. Taylor, Reg. No. 28,992; David M. Kelly, Reg. No. 30,953; Kenneth J. Meyers, Reg. No. 25,146; Carol P. Einaudi, Reg. No. 32,220; Walter Y. Boyd, Jr., Reg. No. 31,738; Steven M. Anzalone, Reg. No. 32,095; Jean B. Fordis, Reg. No. 32,984; Barbara C. McCurdy, Reg. No. 32,120; James K. Hammond, Reg. No. 31,964; Richard V. Burgujian, Reg. No. 31,744; J. Michael Jakes, Reg. No. 32,824; Thomas W. Banks, Reg. No. 32,719; Christopher P. Isaac, Reg. No. 32,616; Bryan C. Diner, Reg. No. 32,409; M. Paul Barker, Reg. No. 32,013; Andrew Chanho Sonu, Reg. No. 33,457; David S. Forman, Reg. No. 33,694; Vincent P. Kovalick, Reg. No. 32,867; James W. Edmondson, Reg. No. 33,871; Michael R. McGurk, Reg. No. 32,045; Joann M. Neth, Reg. No. 36,363; Gerson S. Panitch, Reg. No. 33,751; Cheri M. Taylor, Reg. No. 33,216; Charles E. Van Horn, Reg. No. 40,266; Linda A. Wadler, Reg. No. 33,218; Jeffrey A. Berkowitz, Reg. No. 36,743; Michael R. Kelly, Reg. No. 33,921; James B. Monroe, Reg. No. 33,971; Doris Johnson Hines, Reg. No. 34,629; Allen R. Jensen, Reg. No. 28,224; Lori Ann Johnson, Reg. No. 34,498; and David A. Manspeizer, Reg. No. 37,540 and _____. Please address all correspondence to FINNEGAN, HENDERSON, FARABOW, GARRETT & DUNNER, L.L.P. 1300 I Street, N.W., Washington, D.C. 20005, Telephone No. (202) 408-4000.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

Full Name of First Inventor: Andreas Jagtøyen	Inventor's Signature: Andreas Jagtøyen	Date: 27-09-2001
Residence: Leinstrand		Citizenship: Norwegian
Post Office Address: N-7083 Leinstrand, Norway		

Listing of Inventors Continued on Page 2 hereof. ☐ Yes ☐ No

STATEMENT CLAIMING SMALL ENTITY STATUS
(37 CFR 1.9(f) & 1.27(c)) - SMALL BUSINESS CONCERN

Docket Number:

Applicant, Patentee, or Identifier: _____
Application or Patent No.: _____
Filed or Issued: _____
Title: DEVICE AND SYSTEM FOR MONITORING INTERNAL TEMPERATURE OF....

I hereby state that I am

☐ the owner of the small business concern identified below:
☒ an official of the small business concern empowered to act on behalf of the concern identified below:

NAME OF SMALL BUSINESS CONCERN SensIT AS
ADDRESS OF SMALL BUSINESS CONCERN Ingvald Ystgaards vei 15, N-7047 Trondheim

I hereby state that the above identified small business concern qualifies as a small business concern as defined in 37 CFR Part 121 for purposes of paying reduced fees to the United States Patent and Trademark Office, in that the number of employees of the concern, including those of its affiliates, does not exceed 500 persons. For purposes of this statement, (1) the number of employees of the business concern is the average over the previous fiscal year of the concern of the persons employed on a full-time, part-time, or temporary basis during each of the pay periods of the fiscal year, and (2) concerns are affiliates of each other when either, directly or indirectly, one concern controls or has the power to control the other, or a third party or parties controls or has the power to control both.

I hereby state that rights under contract or law have been conveyed to and remain with the small business concern identified above with regard to the invention described in:

☐ the specification filed herewith with title as listed above.
☒ the application identified above.
☐ the patent identified above.

If the rights held by the above identified small business concern are not exclusive, each individual, concern, or organization having rights in the invention must file separate statements as to their status as small entities, and no rights to the invention are held by any person, other than the inventor, who would not qualify as an independent inventor under 37 CFR 1.9(c) if that person made the invention, or by any concern which would not qualify as a small business concern under 37 CFR 1.9(d), or a nonprofit organization under 37 CFR 1.9(e).

Each person, concern, or organization having any rights in the invention is listed below:

☒ no such person, concern, or organization exists.
☐ each such person, concern, or organization is listed below.

Separate statements are required from each named person, concern, or organization having rights to the invention stating their status as small entities. (37 CFR 1.27)

I acknowledge the duty to file, in this application or patent, notification of any change in status resulting in loss of entitlement to small entity status prior to paying, or at the time of paying, the earliest of the issue fee or any maintenance fee due after the date on which status as a small entity is not longer appropriate. (37 CFR 1.28(b))

NAME OF PERSON SIGNING STEINAR FOSSEN
TITLE IN ORGANIZATION OF PERSON SIGNING MANAGING DIRECTOR
ADDRESS OF PERSON SIGNING SILDRAPEVEIEN 3E, 7048 TRONDHEIM
SIGNATURE Steinar Fossen DATE 27.09.01